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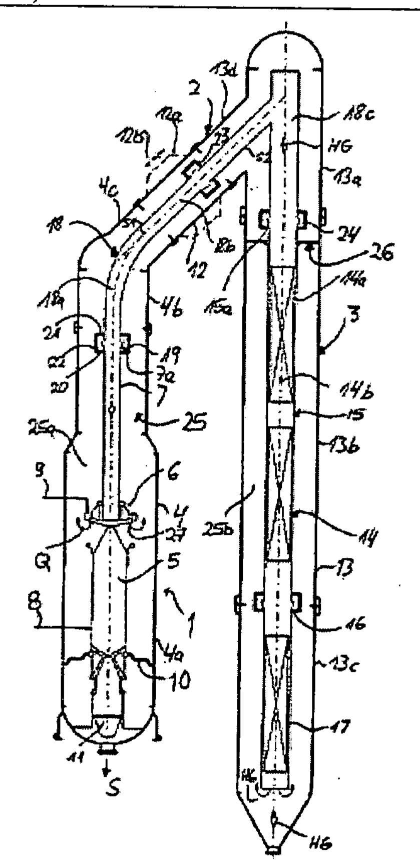
(56) Documents taken into consideration to evaluate patentability:
US 48 59 214

Keintzel, G. and Gawlowski, L.: Criteria for Design of Gasifier and Syngas Cooler, Presentation at the 2002 ECOS Conference, July 5 to 7, 2000, University of Twente, Enschede, NL.

(54) Method for Pressure Balancing in a Coal Gasification Plant and Coal Gasification Plant for Carrying Out the Method

(57) The invention relates to a method for balancing the pressure between the inside of a cooled hot gas guide channel (18), - through which dust-fouled hot gas (HG) flows under pressure and which is downstream of a gasifier module, comprising a cooled gasification reactor (5), a quench gas feed unit (6), and a cooled quench pipe (7), and to which is assigned at least one thermal expansion-absorbing sliding point (19; 23; 24), and which feeds hot gas to at least one heat exchanger heating surface (14), enveloped by a pressure wall, - and an annulus (25; 25a, 25b), which is defined by the gasifier module and the channel and a pressure wall, enveloping said gasifier module and channel, and where the annulus (26), which is shut off downstream from the sliding point, is loaded with a pressurized gas; it is also provided for the purpose of preventing secondary flows in the annulus that the sliding point (19; 23; 24) is designed so as to be gas-tight with respect to the hot gas (HG), guided in the cooled hot gas guide channel (18), and that the annulus (25a), enveloping the gasifier module (5, 6, 7) and the channel (18), is loaded with quench gas (Q), issuing from the quench unit (6) into the annulus (25a).

The invention also relates to a coal gasification plant for carrying out the method.



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Specification

[0001] The invention relates, first, to a method for balancing the pressure between the inside of a cooled hot gas guide channel, - through which dust-fouled hot gas flows under pressure and which is downstream of a gasifier module, comprising a cooled gasification reactor, a quench gas feed unit, and a cooled quench pipe, and to which is assigned at least one thermal expansion-absorbing sliding point, and which feeds hot gas to at least one heat exchanger heating surface, enveloped by a pressure wall, - and an annulus, which is defined by the gasifier module and the channel and a pressure wall, enveloping said gasifier module and channel, and where the annulus, which is shut off downstream from the sliding point, is loaded with a pressurized gas.

[0002] When coal is gasified, the coal is converted into a hot gas (synthesis gas) at a high temperature and under pressure. Some of the inert ash constituents in the coal leave the gasification reactor with the hot gas flow in the form of fine dust. Since the gasification pressure must range up to 50 bar, the components used in the gasification process, like the gasification reactor, quench pipe, hot gas guide channel, and the downstream heat exchanger heating surfaces, are operated inside the pressure wall, which can be realized by means of one or several pressure tank(s) and pressure shell(s). To protect the pressure wall from high synthesis gas temperatures of 1,500 deg. C and more, the gasification reactor, the quench pipe and the gas guide channel are realized with water cooled cooling surfaces. The hot gases, leaving the gasification reactor, are cooled with the cold quench gas, which is added by a quench gas feed unit, by mixing to a temperature of approximately 900 deg. C in the quench pipe that is also cooled. Another cooling process takes place in one or several heat exchanger heating surface(s), thus producing steam.

[0003] Between the gasifier, the quench pipe, the gas guide channel and the heat exchanger heating surfaces, which is downstream from said gas guide channel, and the pressure wall, enveloping said heat exchanger heating surfaces, an annular space, the so-called annulus, is produced.

[0004] The cooling and heating surfaces that are used can withstand only small gas-sided pressure differences. Thus, the pressure between the gas interior of the aforementioned components and the space in essence has to be balanced.

[0005] For this purpose it is known from the presentation "Criteria for Design of Gasifier and Syngas Cooler" held by Dr. G. Keintzel and Mr. Gawlowski, Grad. Eng., at the 2000 ECOS Conference - International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Aspect of Energy and Process Systems, July 5 - 7, 2000, University of Twente, Enschede, Netherlands, figure "Heating Surfaces in the Syngas Cooler, to design the sliding point, assigned to the hot gas guide channel, so as to be open or to provide it with gas-permeable loose-fill packing in order to achieve in this way the pressure compensation at least at one segment of the hot gas guide channel, which is separated by gas baffles in the direction of the pressure wall. Hence, in balancing the pressure, dust-fouled hot gases pass into the space. In an industrial scale coal gasification plant it was found that undesired gas-sided flow (that is, a so-called secondary flow) develops in the loaded space, because the hot gas can cool on the cooling

surface side, facing the space, and on the pressure wall, and the cooled gas can flow back over the sliding point into the gas interior.

The result is an undesired heating up of the areas of the assigned pressure wall and dust depositions in the annulus. This can lead to malfunctions.

[0006] The object of this invention is to provide a method for preventing undesired gas-sided flows and thus dust depositions in the annulus. It is also the object of the invention to provide a coal gasification plant for carrying out the method.

[0007] This problem is solved by designing the sliding point so as to be gas-tight with respect to the hot gas, guided in the cooled hot gas guide channel, and to load the annulus, enveloping the gasifier module and the channel, with quench gas, issuing from the quench unit into the annulus.

[0008] In carrying out the method, according to the invention, the function of the pressure compensation is separated from the function of the sliding point, because the quench gas, used for balancing the pressure, is introduced into the annulus by the quench unit between the gasification reaction and the quench pipe.

[0009] In this respect the function of the pressure compensation is also separated from the two other functions, which may be assigned to the sliding point, that is the expansion function and the separate assembly function. Since the pressure is balanced with cleaned cold quench gas, an inadmissible heating up of the pressure wall (pressure tank parts, pressure shell) can no longer take place and no dust can settle in the annulus. The one or several gas baffle(s) can be disposed in the area of small differential expansions between the assigned pressure wall and the cooled component, so that there is no need for the second function of compensating for the absorption of sizeable differential expansions in the axial direction of the components at the individual sliding point.

[0010] Furthermore, it is expedient that the annulus, which is defined by at least one heat exchanger heating surface and the pressure wall, enveloping said heat exchanger heating surface, and which is shut off from the annulus, loaded with quench gas, is loaded with cooled hot gas.

[0011] Here, too, no inadmissible heating up of the pressure wall can develop, because a secondary flow is effectively stopped. Thus, no sizeable amounts of dust can precipitate in the annulus, enveloping the heat exchanger heating surface. Thus, when a gas-tight sliding point is used between two heat exchanger heating surfaces, the aforementioned advantages in connection with the sliding point, assigned to the hot gas guide channel, also develop.

[0012] Whereas, when the annulus is loaded, as proposed above, with dust-fouled hot hot-gas, the pressure in the annulus is kept somewhat lower than in the gas interior, the process of the invention endeavors to load the annulus by means of the quench gas in such a manner that the gas pressure in the annulus is equal to or somewhat higher than the gas pressure in the gas interior.

[0013] The problem of the invention is also solved with a coal gasification plant exhibiting the inventive features of claim 3.

[0014] This claim discloses, according to the invention, that the sliding point is designed gas-tight with respect to the hot gas, guided in the channel, and that the annulus, enveloping the gasification module and the channel, can be loaded with quench gas, issuing from the quench gas feed unit.

[0015] Preferably it is provided that a sliding point is provided between the quench pipe and the hot gas guide channel and that at least one other sliding point is provided between two hot gas guide channel segments and/or on the end of the hot gas guide channel; and that the ring baffle for shutting off the annulus is arranged downstream of the other sliding point.

[0016] It is expedient that another sliding point in the gas guide channel is arranged in the area of the passage-way; and that this sliding point is assigned preferably an expansion of the pressure shell in order to optimize the use of the function of a separate assembly in the area of this sliding point.

[0017] As stated above, in prior art coal gasification plants the hot gas guide channel is followed by at least one heat exchanger heating surface, enveloped by a pressure wall, in order to cool down even more the gas (product gas). In so doing, there is preferably a sliding point between the hot gas guide channel and the heat exchanger heating surface; and the ring baffle for shutting off the annulus downstream from the sliding point is arranged upstream or downstream from the heat exchanger heating surface.

[0018] Several gas-sided heating surfaces, which are connected in succession and which are enveloped by the same pressure wall, are used in the conventional manner. Preferably the pressure is then balanced between the gas interior in the heat exchanger heating surfaces and the annulus, enveloping said surfaces, with dust-fouled hot gas, which has been cooled beforehand in the heat exchanger heating surfaces. As a consequence of the significantly lower temperatures as compared to the temperatures in the area of the hot gas guide channel, secondary flows can no longer develop and thus sizeable dust depositions in the annulus are ruled out.

[0019] In the event of a plurality of heat exchanger heating surfaces it is expedient to arrange a sliding point between two heating surfaces.

[0020] At this stage the invention shall be explained in detail with reference to the attached figures.

[0021] **Figure** 1 depicts an embodiment of the coal gasification plant, where the gasification module is disposed in a first pressure tank and the heat exchanger heating surfaces are disposed in a second pressure tank, so that the two pressure tanks are connected together by means of an ascending passage-way; and

[0022] **Figure** 2 is a drawing of another embodiment comparable to **Figure** 1 with a sloped passage-way.

[0023] The gasification plant, shown in **Figure** 1, comprises a gasifier **1**, a passage-way **2**, and a gas cooler **3**.

[0024] The gasifier **1** exhibits a vertical pressure tank **4**, in which a gasification reactor **5**, a quench gas feed unit **6** and a quench pipe **7** are disposed. At **8** coal is fed to the gasification reactor; and at **9** quench gas Q is fed to the quench gas feed unit. Quenched hot gas HG issues from the quench pipe. The gasification reactor **5** and the quench pipe **9** /sic/ are equipped with cooling surfaces.

[0025] The bottom end of the gasification reactor **5** is assigned a gas baffle **10**. Furthermore, the removal **11** of slag S takes place at the bottom end of the gasification reactor **5**. The pressure tank **4** comprises the bottom part **4**a and a top part **4**b with a bent connecting piece **4**c, followed by a pressure shell **12**. The gas cooler **3** exhibits a pressure tank **13**, which comprises three tank segments **13**a, **13**b, **13**c. The pressure tank segment **13**a exhibits a downwardly sloped connecting piece **13**d, which together with the connecting piece **4**c and the pressure shell **12** defines the passage-way **2**. In the gas cooler **3**, for example, three heat exchanger heating surfaces **14** are stacked one above the other, when seen in the flow direction of the hot gas HG. The heating surfaces are depicted merely as a schematic drawing and can be designed, for example, as heating surfaces with a cooled gas guide shell **14**a and straight or wound pipe installations **14**b. In the illustrated embodiment, the gas guide shells **14**a of the two top heating surfaces are connected together to form one gas guide shell **15**, which is connected by means of a gas-tight sliding point **16** to the gas guide shell **17** of the bottom heating surface.

[0026] The connection between the quench pipe **7** and the gas guide shell **15** is produced by means of a hot gas guide channel **18**, which extends in a bent segment **18**a into the pressure tank **4**, in a straight line segment **18**b through the pressure shell **12** and the connecting piece **13**d, and is designed in its last segment as a gas deflecting chamber **18**c.

[0027] The inlet end of the gas guide channel **18** has a sliding point **19**, which enables a sliding relative to the quench pipe **7**, which is provided with an expansion **7**a on its outlet end. This expansion is shown schematically as a simple cone.

[0028] The opposite ends of the quench pipe **7** and the gas guide channel **18** are provided with compensator holders **20** and **21**, between which extends a ring compensator **22**, so that the sliding point **19** is gas-tight with respect to the hot hot-gas issuing from the quench pipe. In the passage-way **2** there is in the area of the pressure shell **12** another sliding point **23** between two segments S1 and S2 of the gas guide channel **18**. The segment S1 exhibits on expansion on its outlet end. The construction of the sliding point **23** corresponds to that of the sliding point **19**.

[0029] Between the outlet end of the gas guide channel **18** in the gas cooler **3** and the inlet in the gas guide shell **15** there is another sliding point **24**, which differs from the construction of the sliding point **19** and **23** in that, when seen in the gas flow direction, the expansion **15**a is not on

the outlet end of the gas guide channel **18**, but rather on the inlet end of the guide shell **15**. The construction of the sliding point **15** /sic/ corresponds to that of the sliding point **24**.

[0030] It is possible for the sliding points **19** and **23** to exhibit the expansion on the other gas guide element. Similarly the sliding points **16** and **24** can exhibit the expansion on the downstream inlet end of the gas guide cross section.

[0031] As shown in **Figure** 1, the gasification reactor **5**, the quench pipe **7**, the gas guide channel **18**, the gas guide shell **15** and the gas guide shell **17** are enveloped by an annulus **25**, defined by the pressure tank **4**, the pressure shell **12** and the pressure tank **13**. This annulus is defined, on the one hand, by the ring baffle **10** in the gasifier **1** and is divided, on the other hand, by a ring baffle **26**, which is arranged between the sliding point **24** and the top heating surface **14**, into two partial annuluses **25**a and **25**b.

[0032] Since the sliding points **19**, **23** and **24** are designed gas-tight relative to the dust-fouled hot gas, guided in the gas interior, for proper operation no dust-fouled hot gas may pass into the annulus **25**a.

[0033] For the purpose of balancing the pressure between the gas interior of the gasification reactor **5**, quench pipe **7**, gas guide channel **18**, the annulus **25**a is loaded with quench gas Q, which issues by way of the outlet ports **27** from the quench gas feed unit 6 into the annulus **25**a. The geometry of the outlet ports **27** is chosen as a function of the pressures so that the pressure in the annulus **25**a is equal to or higher than the gas pressure of the hot gas in the gas interior. Since the quench gas enters the annulus at a significantly lower temperature (e.g. 250∘C) than the temperature of the hot gas in the gas guide channel **18** (e.g. 900∘C), no critical heating up of the assigned pressure tank walls can occur. Since the quench gas is dust-free, no dust depositions can develop.

[0034] Downstream of the ring baffle **26**, the annulus **25**b is loaded towards the top in the reverse direction by the hot gas, which is already partially cooled and which is cooled, for example, to a range of 300-250∘C. and leaves on the bottom end of the gas guide shell **17**.

[0035] Since the annulus **25**b is loaded with gas that still contains dust, but which is significantly colder, no secondary flows can develop here as a consequence of the hot gas flows that rise and then cool down.

[0036] As shown in **Figure** 1 with a dashed line, the pressure shell **12** can exhibit an expansion **12**a, which makes it possible to access the sliding point **23** by way of the access port **12**b.

[0037] It is also possible to arrange the ring baffle **26** downstream of one of the heating surfaces **14** and to enlarge in this way the annulus **25**a. It is also conceivable to arrange the ring baffle **26** above the sliding point **24**.

[0038] The embodiment of **Figure** 2 differs from the embodiment according to **Figure** 1 in that the passage-way between the gasifier **1** and the gas cooler **3** is not configured so as to ascend, but

rather to fall. The two general configurations, according to **Figures** 1 and 2 with ascending or falling passage-way **12**, are disclosed in **Figures** 1 and 2 of the US-PS 4,859,214. Even the embodiment, according to **Figure** 2, can have an expansion **12**a.

[0039] Thus, in both embodiments the annulus **25**, defined between the components and the pressure walls, is not loaded with hot gas, issuing from the quench pipe, at any point whatsoever, but rather is loaded with a cold gas, and in particular, on the one hand, in the form of quench gas Q, and, on the other hand, with hot gas that has already cooled down. The loaded subspaces are separated by a baffle in order to rule out a short-circuit between quench gas and cooled hot gas. The position of the installed ring baffle can vary when seen in the flow direction of the hot gas.

Patent Claims

1. Method for balancing the pressure between the inside of a cooled hot gas guide channel, - through which dust-fouled hot gas flows under pressure and which is downstream of a gasifier module, comprising a cooled gasification reactor, a quench gas feed unit, and a cooled quench pipe, and to which is assigned at least one thermal expansion-absorbing sliding point, and which feeds hot gas to at least one heat exchanger heating surface, enveloped by a pressure wall, - and an annulus, which is defined by the gasifier module and the channel and a pressure wall, enveloping said gasifier module and channel, and where the annulus, which is shut off downstream from the sliding point, is loaded with a pressurized gas, **characterized in** that the sliding point is designed so as to be gas-tight with respect to the hot gas, guided in the cooled hot gas guide channel, and that the annulus, enveloping the gasifier module and the channel, is loaded with the quench gas, issuing from the quench unit into the annulus.

2. Method, as claimed in claim 1, characterized in that the annulus, which is defined by at least one heat exchanger heating surface and the pressure wall, enveloping said heat exchanger heating surface, and which is shut off from the annulus, loaded with quench gas, is loaded with cooled hot gas.

3. Coal gasification plant having a gasifier module, comprising a cooled gasification reactor, a quench gas feed unit and a cooled quench pipe, and having a cooled hot gas guide channel, adjoining the quench pipe, for the purpose of feeding hot gas to at least one heat exchanger heating surface, to which at least one thermal expansion-absorbing sliding point is assigned, and having a pressure wall, enveloping the gasifier module and the hot gas guide channel, where the annulus, which is shut off downstream of the sliding point, can be loaded with a pressurized gas, in particular for carrying out the method, as claimed in claim 1 or 2, characterized in that the sliding point (**19**; **23**; **24**) is designed so as to be gas-tight with respect to the gas (HG), guided in the channel (**18**), and that the annulus (**25**a), enveloping the gasifier module (**5**, **6**, **7**) and the gas guide channel (**18**), is loaded with quench gas (**Q**), issuing from the quench gas feed unit (**5**) /sic/.

4. Coal gasification plant, as claimed in claim 3, characterized in that a sliding point (**19**) is provided between the quench pipe (**7**) and the hot gas guide channel (**18**) and that at least one other sliding point (**23**; **24**) is provided between two hot gas guide channel segments and/or on

the end of the hot gas guide channel; and that the ring baffle (26) for shutting off the annulus is arranged downstream of the other sliding point (24).

5. Coal gasification plant, as claimed in claim 3 or 4, characterized in that another sliding point (23) in the gas guide channel is arranged in the area of the passage-way (2); and that this sliding point is assigned preferably an expansion (12a) in the pressure shell (12).

6. Coal gasification plant, as claimed in at least one of the claims 3 to 5, having at least one heat exchanger heating surface, which is downstream from the hot gas guide channel and which is enveloped by a pressure wall, characterized in that a sliding point (24) is provided between the hot gas guide channel (18) and a heat exchanger heating surface (14) and that the ring baffle for shutting off the annulus downstream of the sliding point (24) is arranged upstream or downstream of the heat exchanger heating surface (14).

7. Coal gasification plant, as claimed in at least one of the claims 3 to 6, having at least another heat exchanger heating surface, which is downstream from the first heat exchanger heating surface, and which is enveloped by an identical pressure wall, characterized in that the annulus (25b), which is located downstream from the ring baffle (26) and between the heat exchanger heating surfaces (14) and the pressure shell (13), can be loaded with the hot gas, which has already been cooled down in the heat exchanger heating surfaces.

8. Coal gasification plant, as claimed in at least one of the claims 3 to 7, characterized in that in the event of a plurality of heat exchanger heating surfaces (14) a gas-tight sliding point (16) is assigned between at least two heating surfaces.

9. Coal gasification plant, as claimed in at least one of the claims 3 to 8, characterized in that the gasification module (5, 7) is disposed in a first vertical pressure tank (4) and the heat exchanger heating surfaces (14) are disposed in a second vertical pressure tank (13) and that the passage-way (2) between the two pressure tanks is constructed by means of an ascending or falling pressure shell (12), in which is arranged the hot gas guide channel (18).

2 page(s) of drawings

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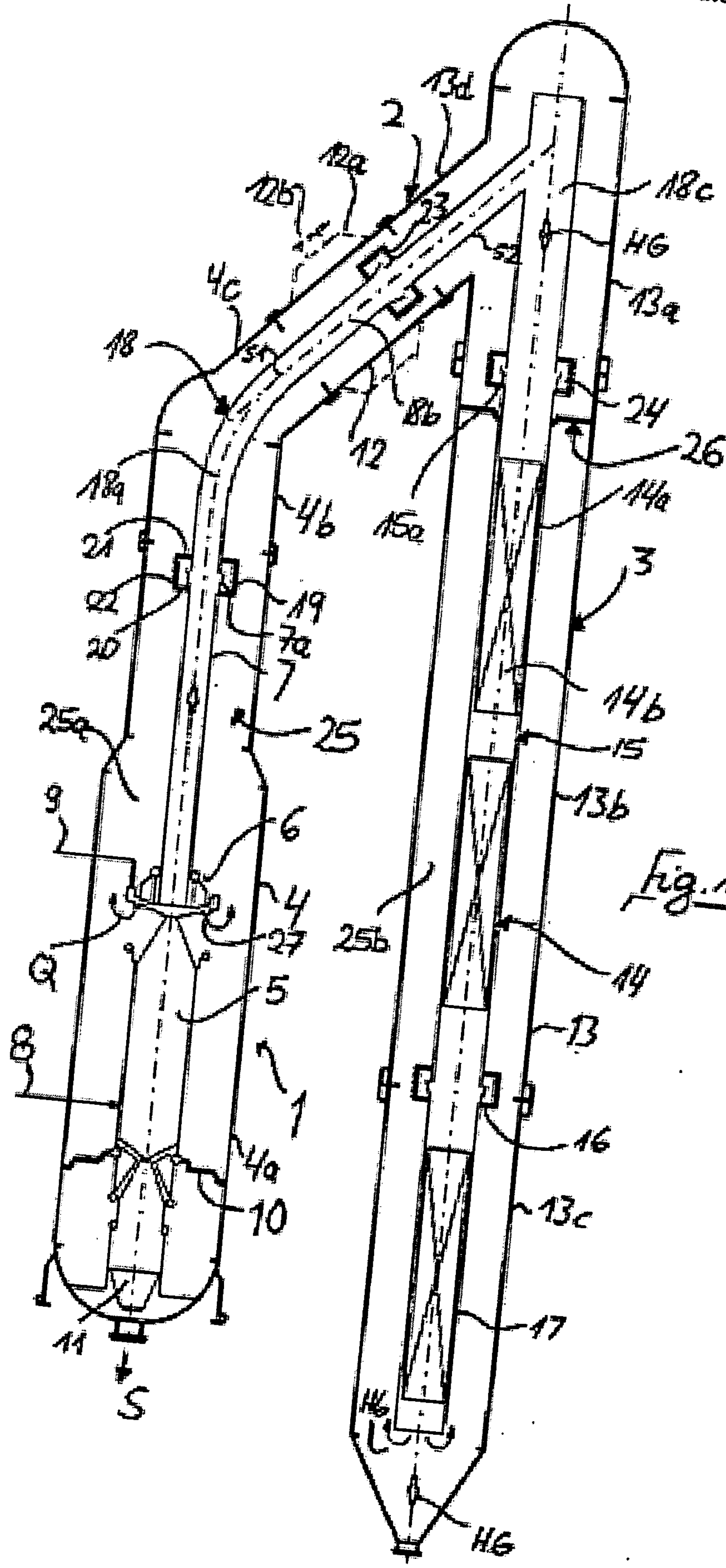

Fig. 1.

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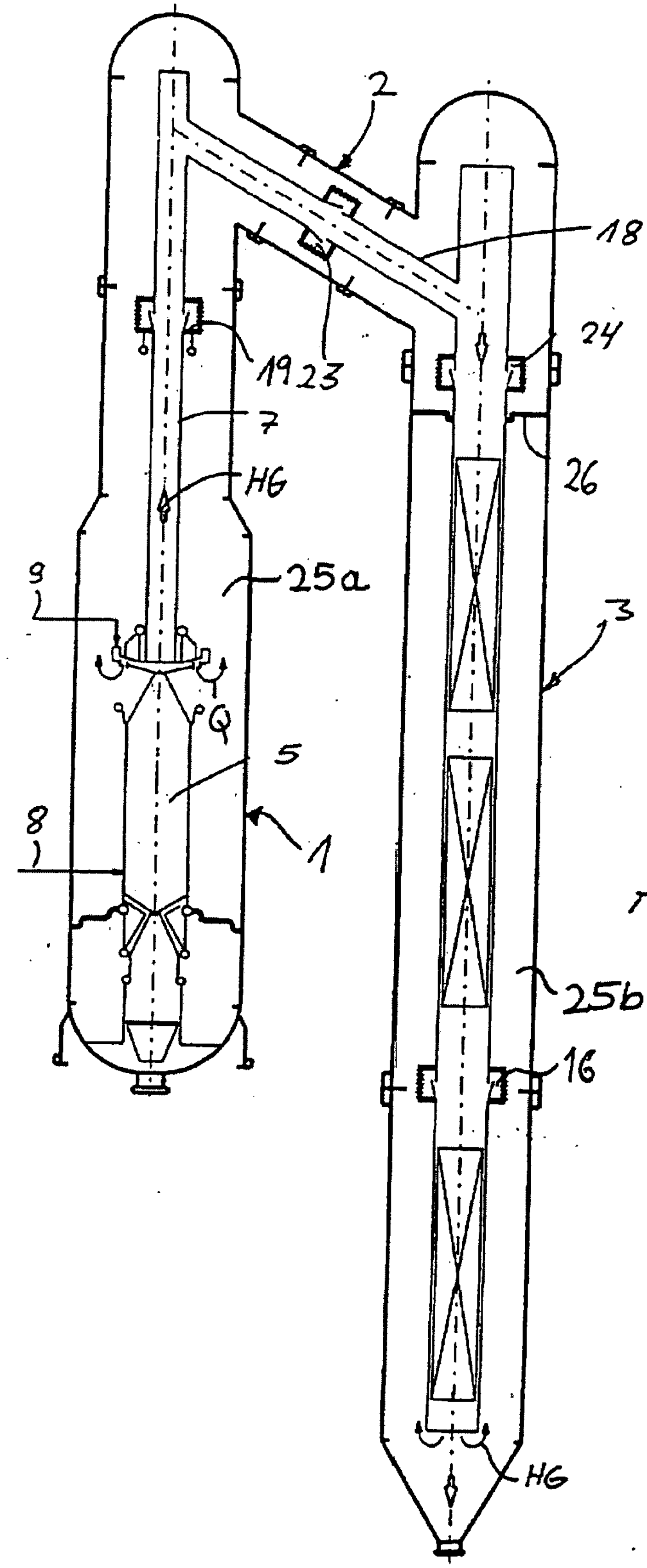

Fig. 2.